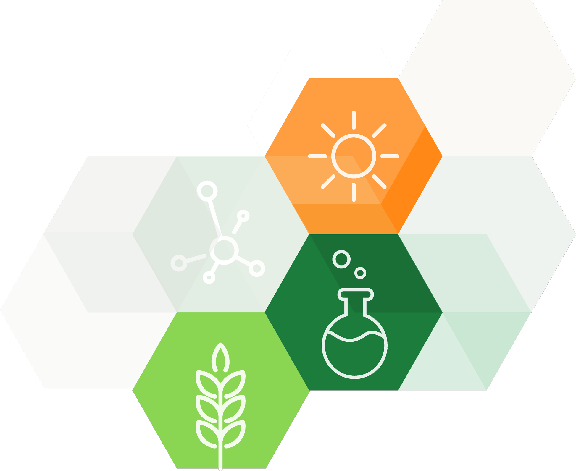
****

**New groundnut varieties for the semi-arid agroecologies of central Tanzania**

**Proposal for submission to variety release committee**

**ICRISAT ESA groundnut breeding programme**

**June 2018**



**Table of Contents**

[Acknowledgements ii](#_Toc517097068)

[SUMMARY iii](#_Toc517097069)

[1. BACKGROUND 1](#_Toc517097070)

[2. STUDY HIGHLIGHTS 1](#_Toc517097071)

[**2.1 The test genotypes** 1](#_Toc517097072)

[**2.2 Description of study locations** 1](#_Toc517097073)

[**2.3 Key results** 2](#_Toc517097074)

[3. DETAILED REPORT NARRATIVE 3](#_Toc517097075)

[**3.1 On station evaluation of genotypes at ARI-Hombolo** 3](#_Toc517097076)

[**3.1.1 Performance during the 2013-14 cropping season** 3](#_Toc517097077)

[**3.1.2 Performance during the 2014-15 cropping season** 3](#_Toc517097078)

[**3.1.3 Performance during the 2015-16 cropping season** 4](#_Toc517097079)

[**3.1.4 Combined genotype performance across seasons** 4](#_Toc517097080)

[**3.1.5 Genotype-by-year Interaction for kernel yield** 5](#_Toc517097081)

[**3.2 On Farm evaluation of genotypes in Kongwa and Kiteto districts** 6](#_Toc517097082)

[**3.2.1 Genotype performance during the 2013-14 cropping season** 6](#_Toc517097083)

[**3.2.2 Genotype performance in the 2014-15 season** 7](#_Toc517097084)

[**3.2.3 Genotype performance in the 2015-16 season** 8](#_Toc517097085)

[**3.2.4 Genotype performance in the 2016-17 season** 9](#_Toc517097086)

[**3.2.5 Additive Main Effect and Multiplicative Interaction (AMMI) analysis of genotypes** 10](#_Toc517097087)

[4. CONCLUSIONS 11](#_Toc517097088)

[5. APPENDICES 12](#_Toc517097089)

[**Appendix 1: Three-year rainfall data for Kongwa and Kiteto** 12](#_Toc517097090)

# **Acknowledgements**

This research activity, in its entirety, was funded through the USAID supported Africa RISING project, led by the International Institute of Tropical Agriculture (IITA) through a subgrant to the International Crops Research Institute for the Semi-arid tropics (ICRISAT).

Implementation on-farm and on-station was done in partnership with the Government of Tanzania’s Ministry of Agriculture Department of Research, Agricultural Research Institutes at Nalendele and Hombolo. The District Agriculture Irrigation and Cooperatives Offices of Kongwa and Kiteto districts and their respective local governments are acknowledged for their unwavering support.

The support by farming communities of Mlali, Moleti, Laikala and Chitego villages (Kongwa District) and Njoro and Kiperesa villages (Kiteto District) is acknowledged.

# **SUMMARY**

Historically, the Manyara and Dodoma regions, were major groundnut producing regions whose place in Tanzania has since slipped way, especially due to limited access to well adapted varieties among others. These regions receive an average of 500 to 700 mm of precipitation per year in good years, but may receive less than 300 mm in bad cropping years. Through Africa RISING, ICRISAT and the Department of Research Agricultural Research Institutes (ARI) at Nalendele and Hombolo have been testing new genotypes of legumes and cereals targeted for these semi-arid agroecologies. The studies were conducted between 2013 and 2017 cropping seasons on-farm and on-station in the region. Five candidate genotypes identified by ICRISAT and ARI- Nalendele from regional adaptability trials were evaluated against the most popular commercial varieties *Pendo* (A Spanish) and or *Mnanje* (Virginia) and the local land race.

The test lines ICGV-SM 02724 and 05650 had the highest kernel yield of 1683, 1303 kg/ha respectively against *Pendo*, the most popular released variety in Tanzania, whose kernel yield was 636 kg/ha. ICGV-SM 02724 had the highest 100 gram seed weight of 55.2 g. ICGV-SMs 02724 and 03519 had the highest haulm yield of 709 and 641 kg/ha respectively. These results confirm on-farm findings in which ICGV-SM 02724, 05650 and ICGV-SM 03519 were the highest yielding material, with over sixty percent (60%) yield advantage over local checks. Through participatory variety selection, farmers rated ICGV-SM 02724 highest due to its high kernel yield, seed size, and tolerance to drought, while ICGV-SMs 05650 and 03519 were preferred for high kernel yield, earliness and good taste. Due to variability observed in the performance of the local check observed in the first three seasons, in 2016-17, the three high performing genotypes were tested against Mnanje a variety released in 2009. The main focus was yield. Significant differences in yield p<0.05 was observed. ICGV-SM 02724 remained the highest yielding genotype. Overall, these new materials (ICGV-SM 02724, ICGV-SM 05650 and ICGV-SM 03519), have potential to enhance production and household resilience and are proposed for release.



ICGV-SM 02724

ICGV-SM 05650

ICGV-SM 03519

Plate 1. Pictures of the new resilient genotypes submitted for variety release, identified from research undertakings in the semi-arid ecologies of central Tanzania.

# **1. BACKGROUND**

The crop-livestock farming systems in semi-arid agroecologies of central Tanzania are in general characterised by low productivity, fragile production-to-market systems, and vulnerable to weather and other natural disaster related challenges. Through Africa RISING, ICRISAT and the ARI-Nalendele and ARI-Hombolo have been testing new varieties of legumes and cereals targeted for these semi-arid agroecologies. To be sure, historically, the Manyara and Dodoma regions, especially Kongwa district, were major groundnut producers from colonial times. Consultations with the District Leaderships (Political and Technical), of Kongwa and Kiteto, both indicated a strong desire to recoup this past glory. These regions receive an average of 500 to 700 mm of precipitation per year in good years, but may receive less than 300 mm in bad cropping years. In 2013, under the project titled, “*Intensification of Cereal-legume based systems in the semi-arid areas of Tanzania to increase farm productivity and improve the farming natural resource base,*” the team begun to undertake strategic studies to develop new adapted material for the semi-arid ecologies of central Tanzania. The work was guided by a broader research hypothesis i.e. *participatory deployment of new agricultural innovations; high yielding resilient varieties and appropriate production practices could catalyse and sustain improvements, with wide benefits to the majority of semi-arid populations.* This report contains major results that emanated from the R&D Investments.

# **2.** **STUDY HIGHLIGHTS**

## **2.1 The test genotypes**

Five genotypes bred by ICRISAT but accessed by the project from ARI-Naliendele, the lead Institution for Oil Seeds Research in Tanzania were evaluated. (see Table 1 for descriptions of these materials.

**Table 1. Description of candidate groundnut lines evaluated for release in Central semi-arid ecologies of Tanzania**

|  |  |  |
| --- | --- | --- |
| Genetic names | Botanical class | Attributes |
| ICGV-SM 02724 | Virginia | Bunch growth habit, red coloured seed coat, tolerant to groundnut rosette and early leaf spot folia diseases, with high yield potential of up to 2500 kg/ha |
| ICGV-SMs 05650, 03519, 01513\* and 99568\*\* | Spanish | Bunch growth habit, tan coloured with seed coat, seed size ranges from small to medium, with yield potential of up to 2000 kg/ha. |

\* ICGV-SM 01513 have been released in Mozambique and \*\*ICGV-SM 99568 released Malawi and Zimbabwe.

All these materials were derived from regional trials for East and Southern Africa, two of which have already been released. They were selected for their wide adaptation.

## **2.2 Description of study locations**

***The agroecology***: Studies were conducted on-station at ARI-Hombolo and on-farm in the districts of Kongwa (Mlali, Moleti, Laikala and Chitego villages) and Kiteto (Njoro village) in Tanzania (Figure 1). Kongwa district is in Dodoma region and lies at 60 10’S, 35O 45’E and 1120 m above sea level, with an average annual precipitation of 556 mm. Kongwa district generally has typical semi-arid conditions, with temperatures averaging about 28OC and annual precipitation of 400-550 mm[[1]](#footnote-1)). Kiteto district is in Manyara region, with weather conditions varying from semi-arid to sub-humid. The annual precipitation averages about 682 mm with temperatures of about 19.50C and altitude ranging from 800-2000 m above sea level. The rainfall, however in Kongwa and Kiteto between 2013 and 2016 recorded on farmers’ fields averaged 202.36 mm per pear (Appendix 1). A soil-health survey conducted in 2015 in both districts, indicated that soils in the focus villages had very low organic matter (0.17-2%) and other major nutrients, with pH ranging from 4-6 (Appendix 6).



Fig 1 Central Tanzania showing target Districts

**Demand**: A Farmer Research Network[[2]](#footnote-2) approach was used to investigate how cropping systems and socio-economic dynamics in farming communities influence adoption of improved groundnuts in Central Tanzania. The study was conducted in Kongwa and Kiteto involving 65 households who provided insights on cropping systems and related social dynamics. The study shows that maize, sorghum, pigeonpea, groundnut, pearl millet and sunflower are the major crops in both districts. Yield estimates for groundnut and pigeonpea are low, with an average of between 500 -700 kg/ha.

## **2.3 Key results**

The results presented are based on evaluation of five genotypes and local checks on-station and on-farmer between 2013 and 2017. The data used to assess performance includes kernel and haulm yield, 100 gram seed weight, days to 75% flowering, shelling percentage and disease scores (groundnut rosette and early leaf spot). The test lines, ICGV-SMs 02724 and 05650 had the highest kernel yield of 1683, 1303 kg/ha respectively against *Pendo*, the most popular released variety in Tanzania, whose kernel yield was 636 kg/ha. ICGV-SM 02724 had the highest 100 gram seed weight of 55.2 g. ICGV-SMs 02724 and 03519 had the highest haulm yield of 709 and 641 kg/ha respectively. These results confirm on-farm findings, in which ICGV-SMs 02724, 05650 and 03519 (Plate 1) were the best yielding varieties with over sixty percent (60% yield) advantage over the local check. Participatory variety selection shows that farmers rated ICGV-SM 02724 highest due to high yield, seed size, and tolerance to drought, while ICGV-SMs 05650 and 03519 were preferred for high yield, earliness and good taste (Appendixes 2 and 3). These varieties have the potential to improve farmers’ resilience to shocks brought about by climate change.

# **3. DETAILED REPORT NARRATIVE**

## **3.1 On station evaluation of genotypes at ARI-Hombolo**

### **3.1.1 Performance during the 2013-14 cropping season**

Significant differences (p<0.05), were observed for yield, shelling percentage, 100 gram seed weight,75 % days to flowering, Groundnut Rosette Disease (GRD) and Early Leaf Spot (ELS) disease scores. However no significant differences were observed for haulm yield (Table 2). ICGV-SM 02724 had the highest kernel yield (2025 kg/ha), followed by ICGV-SM 05650 and ICGV-SM 03519. All the proposed genotypes performed better than *Pendo,* the local check, with kernel yield advantage ranging from 20 to 114%. GRD incidence was generally low, however, *Pendo* recorded an incidence of 4.5% compared to zero for ICGV-SMs 02724, 05650 and 03519.

**Table 2. Genotype performance during the 2013-14 cropping season**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | Kernel yield  (kg/ha) | Shelling % | 100 g seed weight | Early Leaf Spot  incidence | Groundnut Rosette incidence | Haulm yield (kg/ha) | Days to 75% flowering |
| ICGV-SM 01513 | 1165 | 64.61 | 31.94 | 3 | 0 | 550 | 27 |
| ICGV-SM 02724 | 2025 | 75.22 | 59.5 | 0.5 | 0 | 972 | 34.3 |
| ICGV-SM 03519 | 1316 | 61.13 | 32.36 | 2.5 | 0 | 700 | 28 |
| ICGV-SM 05650 | 1604 | 70.7 | 43.18 | 2 | 0 | 578 | 28 |
| ICGV-SM 99568 | 1155 | 62.5 | 41 | 2.5 | 1.5 | 640 | 26.5 |
| Pendo (Check) | 945 | 57.9 | 37 | 3.2 | 4.5 | 400 | 28 |
| Mean | 1320 | 65.32 | 41.41 | 2.25 | 1 | 557 | 27.4 |
| Fpr | 0.004 | 0.003 | 0.002 | 0.012 | 0.001 | 0.219 | 0.001 |
| SED | 183 | 2.38 | 3.4 | 0.5 | 0.408 | 323.6 | 1.12 |
| CV% | 13.9 | 3.7 | 8.2 | 22 | 40.8 | 56.1 | 4.5 |

### **3.1.2 Performance during the 2014-15 cropping season**

Significant differences (p<0.05), were observed only for kernel yield, shelling percentage, 100 gram seed weight and days to 75% flowering, but no significant differences for disease incidence (GRD and ELS) and haulm yield (Table 3). Again the best genotypes for kernel yield were ICGV-SMs 02724 and 05650 (1840 kg/ha and 1435kg/ha respectively) above the local check and site mean. The other three genotypes had kernel yield above the local check but below site mean. All the five had a 100 gram seed weight ranging from 43.5 g to 52.5 g compared to 40 for the check. In terms of earliness, ICGV-SM 03519 had the shortest days to 75% flowering at 26.5 compared to 35.5 for ICGV-SM 02724 and 28 for the check.

**Table 3. Genotype performance during the 2014-15 cropping season**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | Kernel yield  (kg/ha) | Shelling % | 100 g seed weight | Early Leaf Spot  incidence | Groundnut Rosette incidence | Haulm yield (kg/ha) | Days to 75% flowering |
| ICGV-SM 01513 | 1191 | 65.25 | 43.5 | 1 | 0.5 | 511.1 | 27 |
| ICGV-SM 02724 | 1840 | 74 | 52.5 | 0 | 0 | 577.8 | 35.5 |
| ICGV-SM 03519 | 1256 | 62.9 | 45 | 2 | 0 | 612.8 | 26.5 |
| ICGV-SM 05650 | 1435 | 72.5 | 45.5 | 2 | 0 | 527.8 | 28 |
| ICGV-SM 99568 | 1074 | 62.5 | 46.5 | 1 | 1.5 | 708.3 | 27.5 |
| Pendo (check) | 858 | 60 | 40.1 | 2 | 1 | 444.4 | 28 |
| Mean | 1276 | 66.19 | 45.52 | 1.33 | 0.42 | 564 | 28.75 |
| Fpr | 0.001 | 0.008 | 0.042 | 0.364 | 0.194 | 0.104 | 0.001 |
| SED | 111.8 | 2.644 | 2.646 | 1 | 0.645 | 74.1 | 1.118 |
| CV% | 8.8 | 4 | 5.8 | 75 | 54.9 | 13.1 | 3.9 |

### **3.1.3 Performance during the 2015-16 cropping season**

Significant differences (p<0.05) were only observed in 100 gram seed weight and ELS incidence. There was no significant difference in kernel yield, shelling percentage, haulm yield and days to 75% flowering. The genotypes, ICGV-SMs 02724, 05650, 03519 still performed better, with higher kernel yields (1184.6, 870.3 and 851.9 kg/ha respectively) compared to the check and site mean (Table 4). The year also recorded no GRD incidence. For haulm yield, ICGV-SM 99568 had the highest mean of 708.3 kg/ha, while ICGV-SM 02724 remains the best genotype in terms of shelling percentage, 70.5% compared to 62.5% and 64.67% for the check and site mean respectively. The high shelling percentage may also be a contributing factor to its high kernel yield. The yield in this season was lower than the other two seasons due to severe droughts. The average annual rainfall of 107.7 mm was recorded (Appendix 1).

**Table 4 Genotype performance during the 2015-16 cropping season**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | Kernel yield  (kg/ha) | Shelling % | 100 g seed weight | Earl Leaf Spot  incidence | Groundnut Rosette incidence | Haulm yield (kg/ha) | Days to 75% flowering |
| ICGV-SM 01513 | 762.1 | 61.5 | 42 | 2 | 0 | 511.1 | 26.5 |
| ICGV-SM 02724 | 1184.6 | 70.5 | 53.5 | 0 | 0 | 577.8 | 29.5 |
| ICGV-SM 03519 | 851.9 | 63.5 | 42.5 | 2.5 | 0 | 612.8 | 27.5 |
| ICGV-SM 05650 | 870.3 | 69 | 42.5 | 2 | 0 | 527.8 | 26.5 |
| ICGV-SM 99568 | 799.4 | 62.5 | 48.5 | 2.5 | 0 | 708.3 | 27.5 |
| Local | 394.1 | 61 | 38 | 3 | 0 | 444.4 | 27 |
| Mean | 810.4 | 64.7 | 44.5 | 2 | 0 | 564 | 27.4 |
| Fpr | 0.865 | 0.078 | 0.024 | 0.003 |  | 0.104 | 0.865 |
| SED | 2.661 | 3.055 | 3.162 | 0.408 | 0 | 74.1 | 2.661 |
| CV% | 9.7 | 4.7 | 7.1 | 20.4 | 0 | 13.1 | 9.7 |

### **3.1.4 Combined genotype performance across seasons**

Combined analysis shows significant differences, p<0.05 between genotypes for kernel yield, shelling percentage, 100 gram seed weight and disease incidence (ELS and GRD), but no significant differences in haulm yield (Table 5). ***ICGV-SMs 02724, 05650, 03519*** are the best performing genotypes. ICGV-SM 01513, though yielding above the local check, was consistently amongst the lowest two yielders among the 5 test genotypes. The variety was also characterized by small seed size. Their performance in this semi-arid ecologies in Dodoma and Manyara regions, offer opportunity for unlocking productivity in ecologies characterized by unpredictable climate such as these ones.

**Table 5. Combined genotype performance across seasons**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Genotype | Kernel yield  Kg/ha | Shelling % | 100 g seed weight | Earl Leaf Spot incidence | Rosette incidence | Haulm yield (kg/ha) |
| ICGV-SM 01513 | 1040 | 63.78 | 39.15 | 2 | 0 | 524.1 |
| ICGV-SM 02724 | 1683 | 73.24 | 55.17 | 0.167 | 0 | 709.3 |
| ICGV-SM 03519 | 1141 | 62.51 | 39.95 | 2.333 | 0 | 641.9 |
| ICGV-SM 05650 | 1303 | 70.73 | 43.73 | 2 | 0 | 544.4 |
| ICGV-SM 99568 | 1009 | 62.5 | 47.5 | 2 | 1 | 472.2 |
| Local | 636 | 59.6 | 39.3 | 2.667 | 1.8 | 516.7 |
| Mean | 1135 | 65.39 | 44.15 | 1.86 | 0.47 | 568 |
| Fpr | <.001 | <.001 | <.001 | <.001 | 0.009 | 0.515 |
| SED | 170.5 | 1.495 | 2.616 | 0.441 | 0.56 | 135.4 |
| CV% | 26 | 4 | 10.3 | 41 | 76 | 41.3 |

### **3.1.5 Genotype-by-year Interaction for kernel yield**

A genotype x year analysis was performed to assess the respective contribution of genotype, year and genotype x year interaction on kernel yield. Significant differences (p<0.05) were observed for genotype and year effects, while no significant differences were observed for the interaction term (Table 6). This indicates these genotypes are stable across years and are therefore well adapted for these agroecologies.

**Table 6. Genotype by year interaction for kernel yield**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Year | | |
| Genotype | 2013-14 | 2014-15 | 2015-16 |
| ICGV-SM 01513 | 1165 | 1191 | 762 |
| ICGV-SM 02724 | 2025 | 1840 | 1185 |
| ICGV-SM 03519 | 1316 | 1256 | 852 |
| ICGV-SM 05650 | 1604 | 1435 | 870 |
| ICGV-SM 99568 | 1155 | 1074 | 799 |
| Local | 655 | 858 | 394 |
| Mean | 1320 | 1276 | 810 |
| Fpr genotype |  |  | <.001 |
| Fpr year |  |  | <.001 |
| Genotype x year |  |  | 0.284 |
| Sed |  |  | 86.4 |
| CV% |  |  | 13.2 |

### **3.2 On Farm evaluation of genotypes in Kongwa and Kiteto districts**

The five test genotypes evaluated on-station were also tested on-farm using a participatory approach in five villages of Moleti, Laikala, Mlali and Chitego in Kongwa and Njoro in Kiteto district respectively. The trials were conducted using the mother-baby approach. Researcher managed trials (Mother) was laid-out following a randomized complete block design and replicated twice. The researcher managed had all the five test genotypes plus a local check. Whilst the farmer managed trials (baby) had a subset of two farmer selected genotypes and a local check. In total fifty (50) farmers hosted a mother trial, which also acted as learning centres for other farmers. Baby trials were located with a radius of 5 km from the mother trial in each village. Results presented constitute outcomes of the mother trials. Farmers were given chance also to choose own traits for evaluation and out of the listed traits (Appendix 5 and Appendix 6). They were also asked to select and rank the most important traits they look for in a variety (Table 7). Yield, drought tolerance and earliness were the most important traits. The difference between men and women was only on taste and earliness of the genotypes under investigation. In the first three years of on-farm testing, the local check used comprised of seed provided by farmers and to ensure conclusions made were realistic, in 2016-17 season, the genotypes were compared to *Mnanje* (ICGV-SM 83708) a Virginia variety released in Tanzania in 2009 with a known genetic potential (2500 kg/ha) in high potential areas.

**Table 7. Farmer preferred traits and the relative significance in groundnut variety selection**

|  |  |  |  |
| --- | --- | --- | --- |
| Trait | Number of scores | women | Men |
| Yield | 655 | 1 | 1 |
| Seed size | 173 | 5 | 5 |
| Drought tolerance | 572 | 2 | 2 |
| Kernel taste | 420 | 3 | 4 |
| Disease tolerance | 109 | 6 | 6 |
| Earliness (maturity) | 534 | 4 | 3 |
| Seed colour | 97 | 7 | 7 |

### **3.2.1 Genotype performance during the 2013-14 cropping season**

Significant differences (p<0.05) were observed between genotypes for kernel yield and 100 g seed weight. ICGV-SM 02724 was the best yielding genotype (2486 kg/ha), it was followed by ICGV-SM 05650 (1772 kg/ha) against 821 kg/ha and 1563 kg/ha for local check and site mean respectively with a yield advantage over the local check ranging from 65-200 % (Table 8). The two genotypes also had better seed size. Overall the genotypes ICGV-SMs 02724, 03519 and 05650 were most preferred genotypes in that order. ICGV-SM 02724 was mostly preferred for its high yield and tolerance to drought, while ICGV-SM 03519 for its earliness, taste and yield. G x E biplot show that most of the new genotypes were stable across villages compared to the local check (Figure 2). Specifically, ICGV-SM 02724 performed better in Moleti and Mlali. ICGV-SM 99568, though with relatively poor yields, was more stable but specifically for Laikala.

**Table 8. Genotype performance during the 2013-14 cropping season**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Genotypes | kernel yield (kg/ha) | 100 g seed weight | Yield advantage over local (%) | Overall farmer preferences | Reasons for preferences |
| ICGV-SM 01513 | 1384 | 30.46 | 68.57 | 5 | Earliness |
| ICGV-SM 02724 | 2486 | 56.71 | 202.80 | 1 | Yield, drought tolerance |
| ICGV-SM 03519 | 1557 | 35.95 | 115.83 | 2 | Earliness, taste, yield |
| ICGV-SM 05650 | 1772 | 35.99 | 115.83 | 3 | Yield, earliness, drought tolerance |
| ICGV-SM 99568 | 1361 | 43.77 | 65.77 | 4 | Seed size |
| Local | 821 | 31.76 | 0 | 6 |  |
| Mean | 1563 | 39.11 |  |  |  |
| Fpr | <.001 | <.001 |  |  |  |
| sed | 262.1 | 3.153 |  |  |  |
| CV% | 37.5 | 18 |  |  |  |



**Figure 2. 3 G x E biplot for genotypes across villages.**

### **3.2.2 Genotype performance in the 2014-15 season**

Significant differences (p<0.05) were observed for kernel yield and 100 gram seed weight with test genotypes having a yield advantage over the local check from 39 to 116% (Table 9). ICGV-SMs 02724 and 05650 were the best materials with kernel yield of 2046 kg/ha and 1541 kg/ha respectively, above the site and the local check means. The preference ranking by farmers varied slightly from the 2013-14 season as farmers selected ICGV-SM 02724 (yield and drought tolerance) and ICGV-SM 02724 05650 (yield and earliness) in that order. For seed size, ICGV-Ss 02724 and ICGV-SM 02724 99568 had a larger seed size. The G x E biplot grouped the villages into two clusters; Mlali, Moleti, Chitego and Laikala as one group and Njoro as a second cluster (Figure 3). These results imply that using genotypes, we should be able to classify zones and this could be important for appropriate deployment of technologies. The biplot shows ICGV-SMs 02724, 05650 and 03519 as the most stable genotypes with Mlali, Moleti and Chitego as the best environments. The local check showed poor performance and was not as adapted to the villages as the new genotypes.

**Table 9. Genotype performance during the 2014-15 cropping season**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Genotypes | Kernel yield (kg/ha) | 100 g seed weight | Yield advantage over local (%) | Farmer ranking | Reasons for preference |
| ICGV-SM 01513 | 1431 | 30.46 | 51.43 | 4 | Yield, earliness |
| ICGV-SM 02724 | 2046 | 56.71 | 116.51 | 1 | Yield, drought tolerance |
| ICGV-SM 03519 | 1347 | 35.95 | 42.54 | 3 | Yield, taste |
| ICGV-SM 05650 | 1541 | 35.99 | 63.07 | 2 | Yield, earliness |
| ICGV-SM 99568 | 1315 | 43.77 | 39.15 | 5 | Drought tolerance |
| Local | 945 | 31.76 | 0 | 6 |  |
| Mean | 1438 | 39.11 |  |  |  |
| Fpr | <.001 | <.001 |  |  |  |
| sed | 129.9 | 3.153 |  |  |  |
| CV | 20.2 | 18 |  |  |  |



**Figure 3. G x E biplot for 2014-15 cropping season**

### **3.2.3 Genotype performance in the 2015-16 season**

In this season, only three (ICGV-SMs 02724, 03519 and 05650) of the five new genotypes were evaluated on-farm after ICGV-SM 01513 and (ICGV-SM 99568 were rejected for two successive cropping seasons. Data collected included kernel yield, 100 gram seed weight and farmer variety preferences. For both kernel yield and 100 gram seed weight, significant differences (p<0.05), were observed in genotype performance (Table 10). All the three new genotypes yielded above the check and site mean with yield advantage over the check ranging from 112 to 175%. ICGV-SM 02724 was the highest yielding genotype with kernel yield of 1516 kg/ha. It also consistently had larger seed size of 43.5 g against 39.48 g for the local check. Farmers ranked ICGV-SM 02724 as the best material followed by ICGV-SM 05650. The G x E biplot shows that ICGV-SMs 02724 and 05650 were the most stable genotypes, with Mlali, Chitego and Moleti being most favourable environments for these genotypes (Figure 4).

**Table 10. Genotype performance during the 2015-16 cropping season**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Genotypes | Kernel yield (kg/ha) | 100g seed mass | Yield advantage over local (%) | Farmer ranking | Farmer preference |
| ICGV-SM 02724 | 1516 | 43.5 | 175.64 | 1 | Yield, Drought tolerance |
| ICGV-SM 03519 | 1171 | 37.3 | 112.91 | 3 | Yield, earliness, taste |
| ICGV-SM 05650 | 1418 | 40.2 | 157.82 | 2 | Yield, Drought tolerance |
| Local | 550 | 36.9 | 0 |  |  |
| Mean | 1164 | 39.48 |  |  |  |
| Fpr | <.001 | <.001 |  |  |  |
| sed | 190.9 | 0.742 |  |  |  |
| CV% | 36.7 | 4.2 |  |  |  |



**Figure 4. G x E biplot for 2015-16 cropping season**

### **3.2.4 Genotype performance in the 2016-17 season**

Due to variability observed in the performance of the farmer sourced local check in the first three cropping seasons (Figure 5), in 2016-17 cropping season, the three top performing genotypes were tested against *Mnanje* a Virginia variety released in 2009. Yields for the farmer checks ranged from 300 kg/ha to1400 kg/ha while Mnanje ranging from 700 to 1200 kg/ha, but with a higher yield of 1000 kg/ha compared to about 900 kg/ha for the local land race check. Significant differences in yield (p<0.05), was observed. ICGV-SM 02724 remained the best genotype followed by ICGV-SM 03519 with kernel yield of 1486 kg/ha and 1127 kg/ha respectively (Table 11). ICGV-SM 02724 had a yield advantage of 64.93% over *Mnanje*.



**Figure 5. Box plot showing yield variability between Mnanje and the farmer variety**

**Table 11. Genotype performance during the 2016-17 cropping season**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Genotypes | Kernel yield (kg/ha) | Yield advantage (%) | Farmer rank | Farmer preference |
| ICGV-SM 02724 | 1486 | 64.93 | 1 | Yield, seed size |
| ICGV-SM 03519 | 1127 | 25.08 | 2 | Taste, drought tolerance |
| ICGV-SM 05650 | 970 | 7.66 | 3 | Yield, drought tolerant |
| Mnanje | 901 | 0 | 4 | Seed size |
| Mean | 1121 |  |  |  |
| Fpr | <.001 |  |  |  |
| sed | 112.4 |  |  |  |
| CV% | 22.4 |  |  |  |

### **3.2.5 Additive Main Effect and Multiplicative Interaction (AMMI) analysis of genotypes**

Significant difference (p<0.05) were observed for genotypes, environment and genotype x environment interaction in Mlali, Chitego and Moleti, while no significant differences were observed in Njoro. AMMI ranking of varieties shows that ICGV-SM 02724 was consistently ranked first in Chitego, Mlali and Moleti, while in Njoro, ICGV-SM 03519 was ranked first. The overall ranking, however, places ICGV-SMs 02724, 03519 and 05650 as the best genotypes (Table 12). The ranking for second place variety varied across villages however, ICGV-SM 05650 was ranked second in Mlali and Moleti. Results also show that Njoro is a unique environment compared to other villages. The principal components (IPCA 1 and IPCA 11) show that IPCA 1, that scores for genotypes had a higher contribution in the interaction than the environment. This implies that overall performance and or differences of these genotypes is due to genetic causes and therefore a product of plant breeding.

**Table 12. AMMI ranking of genotypes by village**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Genotypes | Chitego | Rank | Mlali | Rank | Moleti | Rank | Njoro | Rank | Overall Mean | Overall Rank |
| ICGV-SM 01513 | 741.88 | 5 | 679.00 | 3 | 315.38 | 4 | 0.00 | 6 | 434.06 | 5 |
| ICGV-SM 02724 | 1251.63 | 1 | 1530.25 | 1 | 883.63 | 1 | 84.88 | 5 | 937.59 | 1 |
| ICGV-SM 03519 | 756.88 | 4 | 960.50 | 2 | 584.25 | 2 | 597.50 | 1 | 724.78 | 2 |
| ICGV-SM 05650 | 980.63 | 2 | 655.75 | 4 | 409.50 | 3 | 150.00 | 3 | 548.97 | 3 |
| ICGV-SM 99568 | 896.50 | 3 | 474.50 | 5 | 305.50 | 5 | 106.25 | 4 | 445.69 | 4 |
| Local variety | 409.50 | 6 | 154.75 | 6 | 168.13 | 6 | 221.63 | 2 | 238.50 | 6 |
| Mean | 839.50 |  | 742.46 |  | 444.40 |  | 193.38 |  |  |  |
| Fpr | 0.0004 |  | 0.005 |  | 0.0055 |  | 0.096 |  |  |  |
| sed | 114.6 |  | 191.2 |  | 104.2 |  | 86.2 |  |  |  |
| Genotypes | | | | | | | | | 0.012 |  |
| Environment | | | | | | | | | <0.001 |  |
| Interaction | | | | | | | | |  |  |
| IPCA 1 | | | | | | | | | 0.0071 |  |
| IPCA 2 | | | | | | | | | 0.0332 |  |

# **4. CONCLUSIONS**

With years of testing both on station and on farmers’ fields, ICGV-SMs 02724, 05650 and 03519 have shown to be the most resilient genotypes in the semi-arid zone of central Tanzania, with potential to unlock groundnut productivity in this region. These varieties had kernel yields consistently high across seasons with yield advantages of up to 64% over Mnanje and over 120% over the farmer checks. The availability of these new varieties could contribute a great deal to food, income and nutrition security. These genotypes also have relatively a higher haulm yield than the local checks and this could be an important trait in the region where livestock keeping is high in the priorities. Additionally, the large biomass in crop residue, could contribute to improving soil fertility, another key area for attention in these agroecologies. These three varieties are therefore recommended for release so that farmers can access well adapted material for the semi-arid agroecologies of central Tanzania.

# **5. APPENDICES**

## **Appendix 1: Three-year rainfall data for Kongwa and Kiteto**

**Appendix 2 Local vs ICGV-SM 05660 Appendix 3 ICGV-SM 02724**

**Appendix 4 Farmers prepare for PVS Appendix 5 PVS in session in Chitego**

**Appendix 6. Results of soil sample analysis for Kongwa and Kiteto**

|  |
| --- |
| **Reference Methods:** pH (CaCl2-1:2.5),Walkley-Black method, Acetate, DTPA extraction, hydrometer method for texture |
| Source: Moleti, Mlali, Laikala, Njoro |

**RESULTS:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Lab No.** | **Farmer** | **Trial** | **Sample No.** | **Depth (cm)** | **Coordinates** | **Elevation** | **pH (CaCl2)** | **OC (%)** | **OM (%)** | **EN (%)** | **P**  **ppm** | **K**  **Meq. %** | **Ca**  **Meq. %** | **Mg**  **Meq. %** | **Texture**  **Class** |
| **40410** | Janet Maleng’a | Baby | 1 | 2 | S=0610979  E=03648285 | 1267 | 5.19 | **0.17** | **0.34** | **0.02** | 36.11 | **0.53** | **2.52** | **0.94** | LS |
| **40411** | Winie Saigodi | Baby | 2 | 2 | S=0610210  E=03648233 | 1266 | 4.85 | **0.14** | **0.28** | **0.01** | 17.15 | **0.48** | **2.10** | **0.64** | LS |
| **40412** | Faith Mahingusa | Baby | 3 | 2 | S=0610988  E03648147 | 1262 | 5.26 | **0.31** | **0.62** | **0.03** | 7.13 | **0.68** | **3.26** | **1.21** | SL |
| **40413** | Msafira | Baby | 4 | 2 | S=0611564  E=03648873 | 1287 | 5.69 | **0.34** | **0.68** | **0.03** | 17.07 | **0.84** | **4.14** | **1.59** | SL |
| **40414** | Moleni Mafuso | Baby | 5 | 2 | S=0610324  E=03648980 | 1282 | 5.91 | **0.11** | **0.23** | **0.01** | 28.83 | **0.77** | **2.78** | **0.71** | LS |
| **40415** | Prisca self | Mother | 6 | 2 | S=0608928  E=03648167 | 1280 | 5.88 | **0.45** | **0.91** | **0.05** | 29.81 | **1.37** | **5.64** | **1.96** | SCL |
| **40416** | Michael Chityange | Baby | 7 | 2 | S=0609329  E=03648362 | 1272 | 5.92 | **0.98** | **1.99** | **0.10** | 7.74 | **2.59** | **9.16** | **2.08** | SL |
| **40417** | Mariam Lebwanya | Baby | 8 | 2 | S=0611951  E=03636330 | 1159 | 5.30 | **0.42** | **0.85** | **0.04** | 21.24 | **0.89** | **3.42** | **1.23** | SCL |
| **40418** | Samuel Mjoeni | Baby | 9 | 2 | S=0611026  E=03636919 | 1192 | 5.40 | **0.31** | **0.62** | **0.03** | 13.28 | **0.74** | **2.78** | **1.14** | SL |
| **40419** | Mwajob Self | Baby | 10 | 2 | S=0611656  E=.3635622 | 1150 | 5.47 | **0.45** | **0.91** | **0.05** | 11.68 | **1.15** | **3.42** | **1.44** | SL |
| **40420** | Ester Malole | Baby | 11 | 2 | S=0613009  E=03637696 | 1200 | 5.23 | **0.67** | **1.36** | **0.07** | 4.70 | **1.11** | **3.28** | **1.43** | SL |
| **40421** | Sekwawo Mulusu | Baby | 12 | 2 | S=0612339  E=03637437 | 1200 | 5.36 | **0.36** | **0.74** | **0.04** | 5.61 | **0.66** | **3.08** | **1.27** | SCL |
| **40422** | Eda Masegele | Baby | 13 | 2 | S=0611490  E=03637209 | 1187 | 5.13 | **0.48** | **0.97** | **0.05** | 6.22 | **0.87** | **3.32** | **1.22** | SCL |
| **40423** | Laikala | Mother | 14 | 2 | S=0611522  E=03636985 | 1196 | 5.15 | **0.45** | **0.91** | **0.05** | 7.97 | **1.28** | **4.10** | **1.55** | SCL |
| **40424** | Janet Malangula | Baby | 15 | 10 | S=0610979  E=03648285 | 1267 | 4.37 | **0.08** | **0.17** | **0.01** | 29.81 | **0.47** | **1.68** | **0.43** | LS |
| **40425** | Winnie Saigodi | Baby | 16 | 10 | S=0610210  E=03648233 | 1266 | 4.68 | **0.08** | **0.17** | **0.01** | 16.08 | **0.45** | **2.46** | **0.64** | LS |
| **40426** | Faith Malungula | Baby | 17 | 10 | S=0610988  03648147 | 1262 | 5.28 | **0.31** | **0.62** | **0.03** | 15.10 | **0.85** | **3.22** | **1.17** | LS |
| **40427** | Msafira Malang’a | Baby | 18 | 10 | S=0611564  E=03648873 | 1287 | 5.95 | **0.28** | **0.57** | **0.03** | 32.92 | **0.65** | **2.64** | **1.01** | LS |
| **40428** | Moleni Mafuso | Baby | 19 | 10 | S=0610324  E=03648980 | 1282 | 5.64 | **0.17** | **0.34** | **0.02** | 22.23 | **0.58** | **2.32** | **0.71** | LS |
| **40429** | Prisca Self | Mother | 20 | 10 | S=0608928  E=03648167 | 1280 | 5.89 | **0.56** | **1.14** | **0.06** | 11.76 | **1.48** | **3.36** | **2.30** | SCL |
| **40430** | Michael Chityaunge | Baby | 21 | 10 | S=0609329  E=03648362 | 1272 | 6.01 | **0.81** | **1.65** | **0.08** | 11.30 | **2.63** | **8.96** | **2.09** | SL |
| **40431** | Miriam Lebwanya | Baby | 22 | 10 | S=0611951  E=03636330 | 1159 | 4.97 | **0.50** | **1.02** | **0.05** | 7.74 | **1.23** | **4.40** | **1.68** | SC |
| **40432** | Samuel Mjoeni | Baby | 23 | 10 | S=0611026  E=03636919 | 1192 | 5.22 | **0.36** | **0.74** | **0.04** | 8.12 | **0.72** | **3.52** | **1.16** | SL |
| **40433** | Mwajob Self | Baby | 24 | 10 | S=0611656  E=03635622 | 1150 | 5.29 | **0.42** | **0.85** | **0.04** | 5.99 | **0.99** | **2.90** | **1.56** | SL |
| **40434** | Ester malole | Baby | 25 | 10 | S=0613009  E=03637696 | 1200 | 5.24 | **0.45** | **0.91** | **0.05** | 8.88 | **1.09** | **2.74** | **1.44** | SL |
| **40435** | Sekwawo Mulusu | Baby | 26 | 10 | S=0612339  E=03637437 | 1204 | 5.39 | **0.34** | **0.68** | **0.03** | 9.48 | **0.72** | **2.92** | **1.22** | SCL |
| **40436** | Eda Masegele | Baby | 27 | 10 | S=0611490  E=03637209 | 1187 | 5.02 | **0.45** | **0.91** | **0.05** | 9.41 | **0.88** | **3.88** | **1.16** | SL |
| **40437** | Lai Kala | Mother | 28 | 10 | S=0611522  E=03636988 | 1196 | 5.19 | **0.48** | **0.97** | **0.05** | 11.23 | **1.27** | **4.14** | **1.62** | SL |

1. See <https://www.climatedata.eu/climate.php?loc=tzzz0019&lang=en>. [↑](#footnote-ref-1)
2. See [www.Mcknight.org](http://www.Mcknight.org) for details [↑](#footnote-ref-2)